

**TRIGONOTYLUS COELESTIALIUM (HETEROPTERA: MIRIDAE), A  
PEST OF SMALL GRAINS: SEASONAL HISTORY, HOST  
PLANTS, DAMAGE, AND DESCRIPTIONS OF  
ADULT AND NYMPHAL STAGES**

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*Abstract.* — *Trigonotylus coelestialium* (Kirkaldy), a holarctic plant bug (Mirinae: Stenodemini), is known as a pest of small grains in the Palearctic Region but has remained little studied in the Western Hemisphere. Presented are a summary of its seasonal history and host plants in Pennsylvania, its relative density in oat fields, the effects of different densities of adults on growth of oat seedlings under greenhouse conditions, and its potential for injuring cultivated grains. Even small numbers of adults (1-2 per 2 seedlings) significantly inhibited growth, and it is concluded that this multivoltine bug is potentially injurious to spring grains. The nymphal stages are described and illustrated; the adult is illustrated and diagnosed with emphasis on its separation from the related *T. ruficornis* (Geoffroy).

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Entomologists are becoming more aware of plant bugs as pests of grasses and small grains. Species of the mirid genera *Irbisia* Reuter (McKendrick and Bleicher, 1980; Schwartz, 1984) and *Labops* Burmister (Todd and Kamm, 1974; Hewitt, 1980) decrease productivity of range grasses in western United States. Feeding occurs mainly on grass blades, causing chlorotic spots in areas of stylet penetration. Other grass-associated plant bugs feed more on culms (stems) or on maturing flower and seed heads. Their injury appears as silvery-white heads that, although mature, produce sterile flowers. Usually referred to as silvertop (or sometimes white ear), this condition results from the piercing of culms before pollination occurs. In North America the agents responsible for silvertop may differ among regions, but mirids often are important causal agents (Arnot and Bergis, 1967; Peterson and Veal, 1971; Kamm, 1979; Gagné et al., 1984). Species implicated in producing silvertop belong mainly to the subfamily Mirinae, except for the phylina *Amblytylus nasutus* (Kirschbaum). Most of the mirines are members of the tribe Stenodemini, e.g., the genera *Leptopterna* Fieber, *Litomiris* Slater, *Megaloceroea* Fieber, and *Stenodema* Laporte. In Europe, the holarctic *Leptopterna dolabrata* (L.) is known to cause silvertop of grasses (Wagner and Ehrhardt, 1961).

Species of the stenodemine genus *Trigonotylus*, often abundant in grasses and small grains, have received little attention in North America, though they have been studied in the Palearctic Region. In the USSR, Agafonova and Belizin (1964)

recorded large populations of *T. ruficornis* (Geoffroy) (3–5/plant) on all corn plants in a 115-hectare plot. Mikhailova (1979) determined the various abiotic and biotic factors influencing population dynamics of *T. coelestialium* (Kirkaldy) in winter wheat, (1980) developed a method of forecasting the occurrence of this cereal pest based on 10-day counts on spring grains and on date of appearance of second generation adults, and (1983) discussed resistant wheat cultivars. Bilewicz-Pawinska (1982) reported on populations of *T. coelestialium* developing in barley, oat, rye, and wheat fields in Poland and on parasitism by three species of the braconid genus *Peristenus* Foerster.

In the North American literature, Watson's (1928) "Miridae of Ohio" included *T. ruficornis* in a list of economically important mirids, stating it is occasionally abundant in wheat and oats. Knowlton (1947) noted the presence of *T. ruficornis* in rye fields in Utah but reported that *Leptopterna ferrugata* (Fallén) was the mirid most often associated with fields showing chlorotic blades. Arnot and Bergis (1967), in studying the silvertop problem in British Columbia, collected only 3 adults of *T. ruficornis* in fields examined but noted that it induced typical silvertop symptoms in the greenhouse. In Pennsylvania this species was the most abundant heteropteran associated with grass sod and various legumes seeded in old-field sward environments (Mangan et al., 1982).

*T. coelestialium*, described from China by Kirkaldy (1902), was later recognized from Germany (Wagner, 1956) and from Poland where it is the most common member of the genus (Korcz, 1979). The first North American records were those of Carvalho and Wagner (1957) from Alaska, Illinois, New York, and Ohio. It is known in Canada from Nova Scotia and Prince Edward Island west to Alberta (Kelton, 1971, 1980) and in the U.S. from New England south to Georgia and Louisiana and west to Wyoming (Kelton, 1971; Stephens, 1982; Snodgrass et al., 1984). *T. coelestialium* has been recorded as common on grasses in Michigan (Niemyzyk and Guyer, 1963), and we have found it is this holarctic species rather than the holarctic *T. ruficornis* that is abundant on various grasses in Pennsylvania. Blinn and Yonke (1982), in reporting tall fescue, *Festuca arundinacea* Schreb., as a host plant in Missouri, noted the probable occurrence of two annual generations. Stephens (1982) considered *T. coelestialium* as univoltine in southeast Wyoming; recorded this species feeding on tufted hairgrass, *Deschampsia cespitosa* (L.) Beauv., and timothy, *Phleum pratense* L.; and also collected it on wheatgrass, *Agropyron intermedium* (Host) Beauv., and on *Poa rupicola* Nash ex Rydb. Snodgrass et al. (1984) listed it from bermudagrass, *Cynodon dactylon* (L.) Pers., in Mississippi.

Owing to confusion with *T. ruficornis* in the Old World (see Wagner 1956; Bozdechova, 1973; Korcz, 1979; Josifov, 1980), it is likely that *T. coelestialium* has been present in Europe longer than published records would indicate. In North America it is unlikely that *T. coelestialium* is a recent invader. Some of the references to *ruficornis* in the economic literature probably refer to *coelestialium*, as does the record of *T. americanus* Carvalho from various grasses and small grains in New York (Hardee et al., 1963).

We summarize here our data on seasonal history, host plants, and habits of *T. coelestialium* in Pennsylvania during 1977–83, including results of a preliminary laboratory study designed to assess its potential for inhibiting the growth of small grains. A diagnosis and illustration of the adult are provided; the nymphal stages are described and illustrated. Voucher specimens are deposited in the collections

of the Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg (BPI, PDA) and the Department of Entomology, U.S. National Museum of Natural History, Washington (USNM).

#### MATERIALS AND METHODS

**Field studies.**—Estimates of the relative density of *T. coelestialium* were obtained in 1977 by taking 100-sweep samples with a standard sweep net from 70 oat fields in 10 central Pennsylvania counties. Most fields were sampled in May and in June. Contents of the net bag were transported to the laboratory in 1-pint ice cream cartons and the numbers of adults and nymphs counted and recorded.

Seasonal history of *T. coelestialium* was followed mainly in the Harrisburg (Dauphin Co.) area. Observations were made at irregular intervals during 1978, 1980, and 1982, and the proportion of adults and various nymphal stages present were estimated in the field. In 1979 a population was sampled weekly or biweekly from early May to mid-August, and in the field 10 or more individuals were "rough sorted" to stage. To determine interplant movements, 50-sweep samples were taken from grasses adjacent to a wheat field and at 8 m and 15 m into the field. In 1983 several populations were sampled similarly from late April to late September and the nymphs preserved in 70% alcohol for sorting to stage in the laboratory. Supplemental early- and late-season collections and host plant observations were made in other areas of the state during 1978–83.

**Laboratory studies.**—In a greenhouse (18.3–26.7°C, 50–90% R.H.) we established oat seedlings in styrofoam pots (2 seedlings/pot) and introduced adult bugs at different densities to determine whether their feeding could stunt plant growth. Clear plastic (Mylar) cylinders covered at the top with fine nylon mesh were placed over the mirid-infested seedlings. In experiment 1 seeds were sown on 22 June 1979 and bugs introduced one week later. In the second experiment seeds were sown on 12 July 1979 and bugs introduced on 18 July.

In experiment 1 we examined the treatment effects of 0 (control), 6 (3 males, 3 females), and 12 (6 males, 6 females) bugs on plant growth using a randomized complete block design. In experiment 2 the number of bugs introduced was 0 (control), 1 (either sex), and 2 (1 male, 1 female). Each treatment included 4 repetitions, each represented by a pot of 2 seedlings. Two samples/repetition were included, with each sample consisting of the measurement of one seedling (in cm). We measured seedling height daily (except on weekends) from soil surface to tip of highest leaf and replaced any dead individuals with bugs of the same sex. For analysis we compared seedling height after 15 days with that when bugs were introduced (labeled "Mean difference in seedling growth" in Tables 2, 3). Treatment effects were analyzed by the Waller-Duncan K-ratio *t* test (Duncan, 1975).

#### BIOLOGY

**Seasonal history and host plants.**—The following account is based on several years' observation and sampling of *Trigonotylus coelestialium* in Pennsylvania, but we caution that phenology in *Trigonotylus* spp. is difficult to characterize. In the USSR, Roshko (1976) reported a univoltine population of *T. ruficornis* at high altitudes and the production of 2 or 3 generations in low-lying areas. Mikhailova (1979) stressed the indirect effects of weather and direct effects of Soviet agricultural practices on population dynamics of *T. coelestialium*. In the USSR the





Fig. 1. Grassy strip (tall plants) growing between two oat fields (foreground and background), which often harbors overwintering eggs and first generation of *T. coelestialium*.

hatching of overwintered eggs and appearance of adults varied as much as 30 days during a 4-year period. In an early season when second generation adults appeared in July, a third generation was produced, but because winter and early summer crops had been harvested, suitable oviposition sites were scarce. The forced deposition of eggs on decaying grains or on roadside grasses that would be mowed or tilled resulted in a small, patchily distributed brood and little accumulation of overwintering eggs in winter grains. In years of bivoltine populations when second generation adults did not appear until August, more eggs were deposited in winter grains, resulting in larger numbers of bugs in crop fields the following spring. In Mikhailova's words, man's agricultural activity allows uninhibited reproduction of this pest while depriving it of a suitable place for further reproduction.

In central Pennsylvania overwintered eggs began to hatch from mid-April to early May. By the first week of May instars II–IV usually were present, and the first adults appeared from mid- to late May. On the same grass species, overwintered eggs of *Amblytulus nasutus*, *Leptopterna dolabrata*, and *Megaloceroea relicticornis* (Geoffroy) hatched at nearly the same time, but adults of *T. coelestialium* were the first grass-feeding mirids to appear. The first generation developed mainly on various native or naturalized grasses bordering crop fields (Fig. 1), only rarely in winter grains that typically are planted in late September through October, or after most previous-season females have oviposited. The small number of first generation bugs that we found developing in small grains may be attributed to migration of nymphs from adjacent grasses, as Bilewicz-Pawinska (1982) observed

Table 1. Relative densities of *Trigonotylus coelestialium* in central Pennsylvania oat fields in 1979.

| County         | No. of Fields         |                       | Mean No. <i>Trigonotylus</i> /100 Sweeps $\pm$ SE (Range) |                             |
|----------------|-----------------------|-----------------------|---|-----------------------------|
|                | Sample 1 <sup>a</sup> | Sample 2 <sup>b</sup> |   |                             |
|                |                       |                       | Early Sample  | Late Sample                 |
| Adams          | 0                     | 4                     | — <sup>c</sup>  | 67.8 $\pm$ 27.8 (9–139)     |
| Cumberland     | 2                     | 4                     | 3.5 $\pm$ 0.5 (3–4)                                       | 96.8 $\pm$ 89.2 (1–364)     |
| Dauphin        | 3                     | 3                     | 47.0 $\pm$ 19.7 (14–82)                                   | 91.9 $\pm$ 16.7 (60–117)    |
| Franklin       | 4                     | 7                     | 11.8 $\pm$ 5.1 (1–25)                                     | 83.1 $\pm$ 40.0 (4–301)     |
| Lancaster      | 13                    | 13                    | 29.0 $\pm$ 5.3 (0–60)                                     | 49.8 $\pm$ 11.0 (12–142)    |
| Lycoming       | 0                     | 10                    | —   | 214.2 $\pm$ 146.5 (17–1523) |
| Northumberland | 1                     | 4                     | 87.0 $\pm$ 0  | 438.2 $\pm$ 322.7 (89–1405) |
| Snyder         | 0                     | 4                     | —   | 95.0 $\pm$ 51.0 (17–243)    |
| Union          | 5                     | 5                     | 93.2 $\pm$ 19.8 (53–167)                                  | 216.6 $\pm$ 88.4 (39–497)   |
| York           | 16                    | 16                    | 35.9 $\pm$ 6.7 (8–90)                                     | 204.5 $\pm$ 50.0 (18–619)   |

<sup>a</sup> Taken 11–27 May.

<sup>b</sup> Taken 15–29 June.

<sup>c</sup> No sample taken.

in Poland. Some females of the first generation deposit eggs on wild grasses, but the majority appear to invade small grains such as winter wheat, winter barley, oats, or rye. Occasionally, adults dispersed to feed on nectar or pollen of nearby plants, e.g., on inflorescences of staghorn sumac, *Rhus typhina* L. Flight capacity in *Trigonotylus* apparently is well developed. *T. ruficornis*, although the least abundant of Stenodemini at England's Rothamsted Experimental Station, exhibited the highest level of flight activity among stenodemine mirids caught in suction and light traps (Southwood, 1960).

We found eggs of a probable second generation within leaf sheaths of oats during late May. First instars of this generation appeared as early as 7 June and were common in mid- to late June. The abundance of second generation *T. coelestialium* in small grains was consistently greater than in the first generation, which is consistent with Mikhailova's (1979, 1980) observations on this mirid in the USSR. The numbers we found in oats—often 1/sweep and sometimes 14–15/sweep (Table 1)—are similar to those of the second generation recorded by Mikhailova (1980). During late June we also observed large numbers in mature wheat, with the bugs concentrated on heads and on the partially green stems just beneath. Based on the observations of Sannikova and Garbar (1981) in the USSR, *T. coelestialium* may inflict considerable injury to the heads of cereal crops. With the cutting of barley, wheat, and rye from mid-June to mid- or late July, second generation adults dispersed widely to wild grasses and corn. The harvesting of grain probably is responsible for considerable *Trigonotylus* mortality. On grasses a third generation began to develop as early as mid-July in 1979. During late July of other years, the small numbers of adults taken in samples and discovery of eggs help confirm the mid- to late July beginning of another generation. In most years populations remained in oat fields, which often were not harvested until early or mid-August.

With the overlapping of successive broods, delineating generations became more difficult as the season progressed, but the appearance of first and second instars in late August 1983 marked the beginning of a fourth generation. The nymphs (instars II–V) observed through late September probably all belonged to this



Fig. 2. Rows of *T. coelestialium* eggs in leaf sheath of oats.

generation, which always seemed fewer in number than preceding ones. The abundance of *T. coelestialium* may well have been less than earlier in the season, although the scattering of populations on numerous hosts accentuated the perception of diminished numbers. Nymphs seldom were taken after late September or early October. Adults were rarely seen during October; our latest records are 29 October and 14 November.

In addition to the crop plants mentioned above—barley, corn, oats, rye, and wheat—*T. coelestialium* develops occasionally on timothy. As breeding hosts it also uses various grasses growing in moist and dry habitats. Along roadsides and at the periphery of fields we found nymphs on *Anthoxanthum odoratum* L., *Agrostis stolonifera* L., *Dactylis glomerata* L., *Digitaria sanguinalis* (L.) Scop., *Eleusine indica* (L.) Gaertn., *Panicum dichotomiflorum* Michx., and *Setaria viridis* (L.) Beauv. In dry ballast along railroad tracks host plants observed were *Agrostis stolonifera* var. *palustris* (Huds.) Farw., *Cynodon dactylon*, *Eragrostis minor* Host, *E. pectinacea* (Michx.) Nees, *Panicum capillare* L., and *Setaria viridis*. In a wet area along a railroad we found adults and nymphs on *Echinochloa muricata* (Beauv.) Fern. *T. coelestialium* occurred most often on these native and naturalized grasses during the first generation and in August and September when small grains had been harvested. Although the host range is rather broad in the Poaceae, *T. coelestialium* seems to prefer certain species, e.g., *Eragrostis minor*, and was rarely collected on annual bluegrass, *Poa annua* L., or on Kentucky bluegrass, *P. pratensis* L.

Laboratory observations and host injury.—The bugs mated on oat seedlings, the pairs orienting side by side with the male displaced to the female's right and his abdomen bent under the female's. Kullenberg (1944: Taf. 11, Fig. 5) illustrates



Fig. 3. Experimental oat seedlings used to determine effects of feeding by *T. coelestialium*: Controls (four pots on left) were free of bugs; seedlings at right contained one adult per pot.

this position in *T. ruficornis* observed in Sweden. Eggs were deposited in rows within leaf sheaths (Fig. 2), often at the base of a plant near soil level. Rows of 4–10 and occasionally more than 20 were observed. In one timed oviposition, 4 eggs were laid in 61 seconds (range 13–18/egg,  $\bar{x} = 15.2$  sec). Mirids that insert their eggs into plant stems, rather than in leaf sheaths, require considerably more time for oviposition, e.g., *Macrolophus separatus* Blatchley on hayscented fern, *Dennstaedtia punctilobula* (Michx.) Moore (Wheeler et al., 1979), and several species on apple, *Malus sylvestris* P. Mill. (Knight, 1915).

*T. coelestialium* fed on seedling stems and blades, and with 6 and 12 bugs/pot (experiment 1) foliar chlorosis appeared after 4 days. Browning of seedling tips and dark fecal spotting on blades were apparent within 6 days. With 1 or 2 bugs/pot (experiment 2) mottling appeared within 5 days. In addition to causing extensive chlorosis and browning, the bugs inhibited seedling growth (Fig. 3). For experiments 1 and 2 there were no significant statistical interactions between repetitions and main treatment effects ( $P = 0.05$ ), and repetition effects also were insignificant. But, at the 5% level in experiment 1 there was a significant difference between the controls and treatments 1 and 2, with plant height of controls greater than either 1 or 2. No significant difference was found between the two treatments (Table 2). At the 5% level in experiment 2 there was a significant difference among all treatment effects (Table 3); seedling height of controls was significantly greater than that of either treatment. Treatment 1 seedling height was less than in controls but greater than for treatment 2, with average height of treatment 2 seedlings less than for the controls or treatment 1.



Table 2. Effects of *Trigonotylus coelestialium* on growth of oats after 15 days using 0, 6, and 12 adults/pot of 2 seedlings.

| Treatment       | Mean Difference in Seedling Growth (cm) <sup>1</sup> (Range) |
|-----------------|--|
| Control: 0 bugs | 35.4 a (27.6–39.7)   |
| No. 1: 6 bugs   | 7.5 b (3.8–11.1)   |
| No. 2: 12 bugs  | 5.7 b (1.3–11.4)   |

<sup>1</sup> Values followed by different letters are significant ( $P = 0.05$ ).

Discussion.—Under laboratory conditions, it is apparent that 1 or 2 *T. coelestialium* adults/pot of 2 seedlings can significantly retard plant growth. In the field this mirid usually was one of the most abundant insects we collected in sweep net samples from small grains. Although populations of 1–2 and even 14 and 15/ sweep were encountered, these levels were attained only in the second generation when winter grains were well established. In central Pennsylvania most small grains, except oats, are planted in the fall; there is little spring wheat or barley. As already discussed, the number of first generation *T. coelestialium* developing in winter grains is small. But because the bugs may invade oats when plants are relatively young, deleterious effects on plant growth are possible. In areas where spring grains are common this plant bug may pose more of a threat to crop development.

As Osborn (1916) pointed out, “insect depredations on grass are of such a character as to escape recognition” because the species involved are mostly small, the obscure nature of their attack consists of a steady drain on hosts and rarely results in plant destruction, and any damage that might be noticed is likely to be attributed to adverse weather, soil deficiency, or some physiological problem. Additional field and laboratory studies similar to those of Quisenberry and Yonke (1981a, b) for assessing the morphological and physiological response of tall fescue to feeding by the leafhopper *Forcipata loca* DeLong & Caldwell are needed to quantify the effects of feeding by *T. coelestialium* on vegetative and reproductive structures of small grains.

#### DESCRIPTIONS

Adult (Fig. 4).—Male [female measurements in parentheses]: Length 5.25–5.75 mm (6.00–6.50 mm). Head: Width 0.66–0.72 mm (0.76–0.80 mm), vertex 0.34–0.36 mm (0.40–0.44 mm). Rostrum: Length 1.72–1.76 mm (1.92–1.96 mm),

Table 3. Effects of *Trigonotylus coelestialium* on growth of oats after 15 days using 0, 1, and 2 adults/pot of 2 seedlings.

| Treatment       | Mean Difference in Seedling Growth (cm) <sup>1</sup> (Range) |
|-----------------|--|
| Control: 0 bugs | 33.7 a (29.3–38.7)   |
| No. 1: 1 bug    | 13.8 b (2.3–29.2)  |
| No. 2: 2 bugs   | 8.9 c (5.5–14.2)   |

<sup>1</sup> Values followed by different letters are significant ( $P = 0.05$ ).



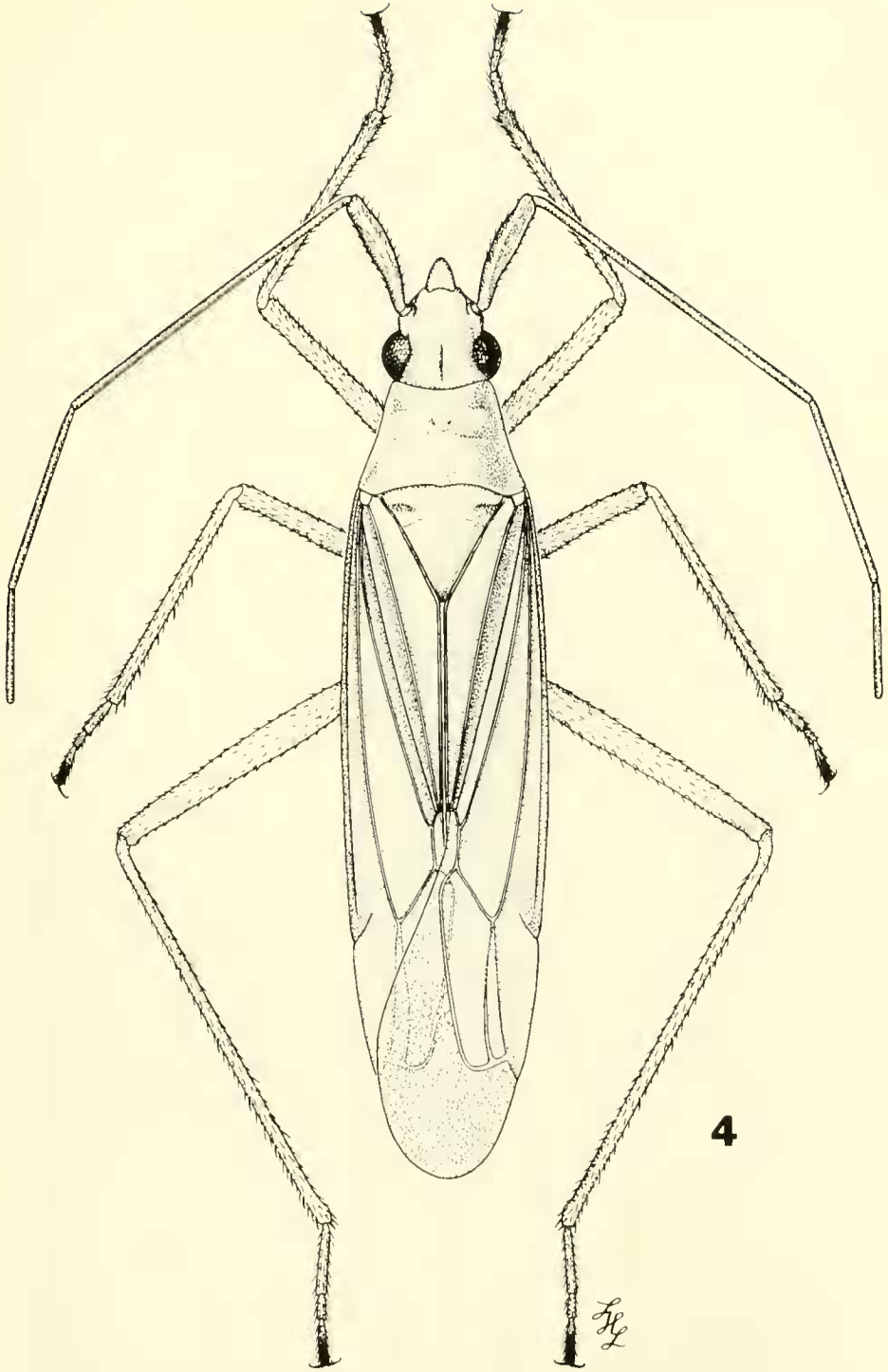


Fig. 4. Adult male of *T. coelestialium*.

extending to metacoxae. Pronotum: Basal width 0.52–0.60 mm (0.56–0.60 mm), mesal length 0.46–0.52 mm (0.64–0.68 mm). Antenna: Length, segment I 0.68–0.70 mm (0.68–0.76 mm); II, 2.00–2.12 mm (2.00–2.36 mm); III, 1.84–1.88 (1.71–2.12 mm); IV, 0.36–0.52 mm (0.64–0.72 mm).

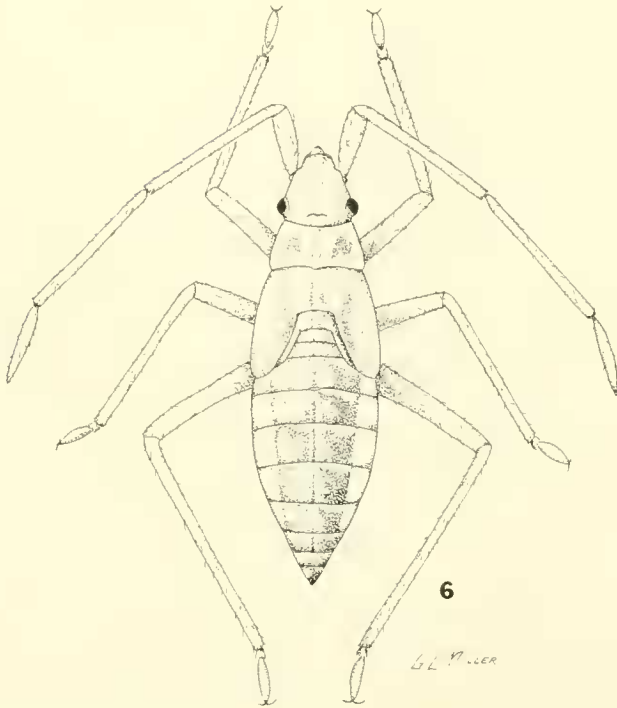
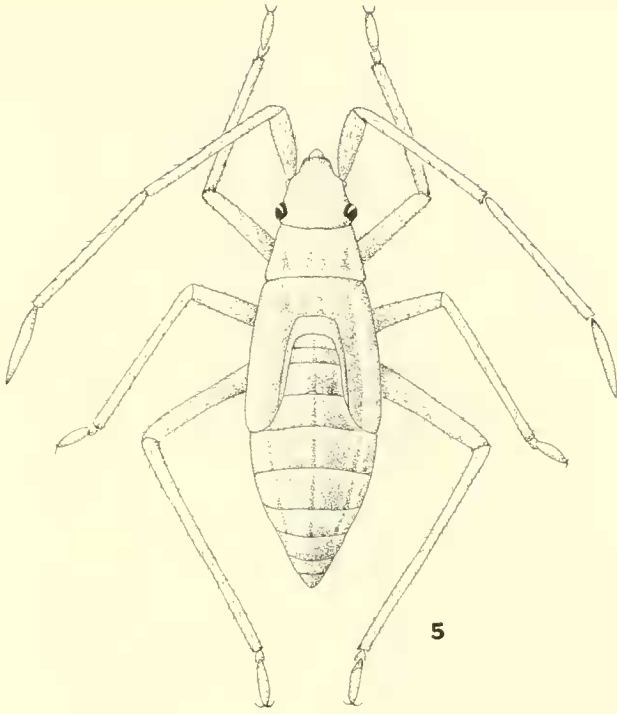
Nearly uniformly green, mesal groove of head, narrow line behind each callus, and border of mesal line on pronotum and scutellum diffused brown, legs green with apical  $\frac{1}{4}$  of metatibiae and most of metatarsi red, antennae red with 3 pale stripes on segment I; dorsum glabrous, alutaceous except finely punctate pronotum; antennal segment I sparsely set with short, recumbent, black setae, segments II–IV thickly set with short, fine brown to golden setae, legs with sparse, recumbent, pale to brownish setae, tarsal spines fine, blending in with setae.

Remarks.—*T. coelestialium* is the most common species of the genus in northeastern United States. Most of the American literature referring to *T. ruficornis* before Kelton's (1971) revision should be applied to *T. coelestialium*. Carvalho and Wagner (1957) suggested that *T. ruficornis* did not occur in North America, but Kelton (1971) clarified that it occurs across northern North America from Quebec to Alaska, and considered *T. viridis* (Provancher) and *T. montanus* Carvalho junior synonyms.

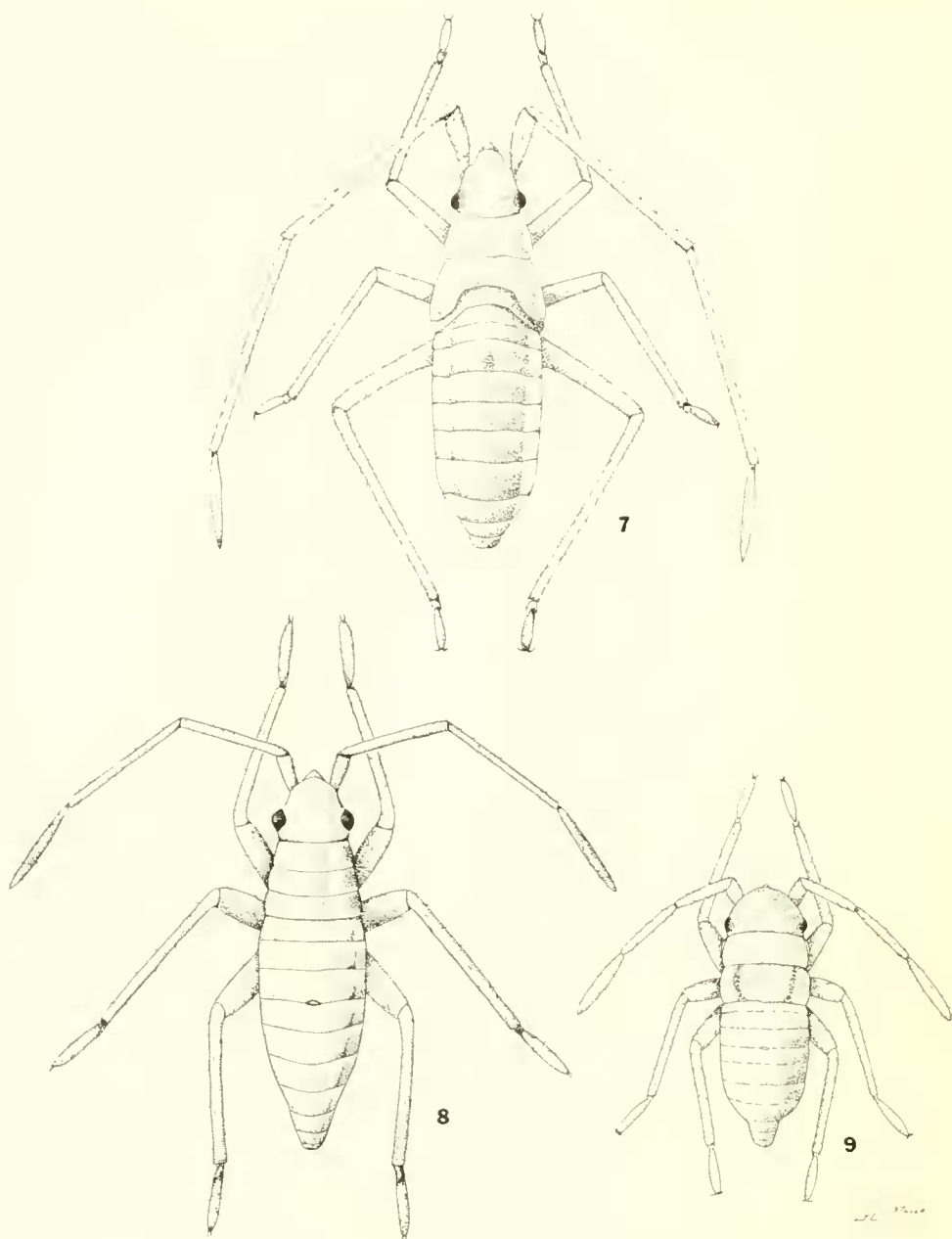
*Trigonotylus coelestialium* can be separated from all other species of *Trigonotylus* in eastern United States by the red antennae with three distinct, broad, pale stripes on segment I, the apically red hindtarsi, the relatively large size (5.25–6.50 mm) with the rostrum measuring more than 1.70 mm, and the aedeagus lacking a spiculum. *Trigonotylus ruficornis* lacks the distinct pale stripes on antennal segment I, is on the average slightly larger (length 5.60–6.65 mm as given by Kelton, 1971), and has a distinct, thickened spiculum on the aedeagus.

Fifth instar (Fig. 5).—Length 3.83–5.00 mm. Head: Width 0.68–0.76 mm; vertex 0.40–0.44 mm. Rostrum: Length 1.48–1.76 mm, extending just past bases of metacoxae. Antenna: Segment I, length 0.48–0.60 mm; II, 1.44–1.64 mm; III, 1.60–1.76 mm; IV, 0.60–0.68 mm. Body coloration green to pale green; mesal impression between eyes, narrow line on either side of meson of thoracic segments, and broad stripe on each side of pronotum continuing onto inner half of forewing pads brownish; legs greenish, tinged pale brown, especially tibiae, metatibiae reddish, tarsi brown to dark brown, claws fuscous, antennae uniformly reddish except pale 1st segment having 3–4 broad red stripes; pronotum well developed, wing pads extending to middle of 4th or base of 5th abdominal segment; dorsal abdominal scent gland opening weakly brownish (as in all instars); legs and antennae sparsely set with short, recumbent, black bristles; body nearly glabrous, with very short, scattered setae, slightly longer setae evident on distal two abdominal segments.

Fourth instar (Fig. 6).—Length 2.84–3.80 mm. Head: Width 0.56–0.60 mm; vertex 0.30–0.36 mm. Rostrum: Length 1.24–1.36 mm, extending to bases of metacoxae. Antenna: Segment I, length 0.38–0.44 mm; II, 1.00–1.12 mm; III, 1.10–1.32 mm; IV, 0.54–0.62 mm. Body coloration green, similar to instar V but lacking much of the darker brown and green markings, legs green, tibiae brown, with metatibiae faintly tinged with red, tarsi brown, apex of 3rd tarsal segment and claws fuscous, antennae green to pale brown tinged with red, segment I with 3–4 red stripes; body nearly glabrous, legs and antennae with very short, sparse, fuscous setae.



Figs. 5, 6. Nymphs of *T. coelestialium*. 5, Fifth instar. 6, Fourth instar.



Figs. 7-9. Nymphs of *T. coelestialium*. 7, Third instar. 8, Second instar. 9, First instar.

Third instar (Fig. 7).—Length 2.12–2.48 mm. Head: Width 0.48–0.50 mm; vertex 0.28–0.30 mm. Rostrum: Length 1.02–1.08 mm, extending to base of 2nd abdominal segment. Antenna: Segment I, length 0.28–0.30 mm; II, 0.60–0.64 mm; III, 0.80–0.84 mm; 0.52–0.58 mm. Body and legs green, thoracic nota darker green with mesal line pale, claws and apices of tarsi dark brown or fuscous, head



and antennae green to pale brown, segment IV red; pronotum quadrate, longest of thoracic segments, meso- and metanota subequal, emarginate, with distinct wing pads; setae short, dark, indistinct.

Second instar (Fig. 8).—Length 1.60–1.88 mm. Head: Width 0.44–0.46 mm; vertex 0.26–0.30 mm. Rostrum: Length 0.76–0.80 mm, extending to 3rd or base of 4th abdominal segment. Antenna: Segment I, length 0.16–0.20 mm; II, 0.40–0.42 mm; III, 0.50–0.52 mm; IV, 0.46–0.48 mm. Body and legs greenish, with head and thoracic nota tinged with darker green, mesal line pale, antennae green, slightly tinged with pale brown or red, segment IV red, claws and apices of tarsi dark brown; pro- and mesonota about of equal length, metanotum slightly shorter (wing pads lacking); setae on head, thorax, and abdomen short, erect, fuscous, proportionately shorter and more slender than for instar I.

First instar (Fig. 9).—Length 1.17–1.36 mm. Head width 0.32 mm (for all specimens measured); vertex 0.22 mm (for all specimens measured). Rostrum: Length 0.64–0.68 mm, extending to 4th or 5th abdominal segment. Antenna: Segment I, length 0.12–0.14 mm; II, 0.22–0.24 mm; III, 0.32 mm (for all specimens measured); IV, 0.36–0.38 mm. Body and legs green, thoracic nota tinged with brown or darker green, antennae green to slightly pale brown, segments II–IV sometimes tinged with red, claws and apices of tarsi dark brown; pro-, meso-, and metanotum about equal in length (wing pads lacking); each notal segment with a transverse row of 4 or 5 long, erect, fuscous setae, head with several scattered, erect, fuscous setae, including a transverse row between eyes, abdomen and apices of femora with scattered pale to fuscous setae.

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